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75TH MORSS CD Cover Page

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War Reserve Munitions Requirement Model (WRMR)

Verification & Validation

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Operations Analysis Division (OAD)
Marine Corps Combat Development Command (MCCDC)

75th MORSS
WG-19

Agenda

- **Purpose**
- **Background**
- **WRMR Model Process**
- **V&V Techniques**
- **Recommendations**
- **Lessons Learned**

Purpose

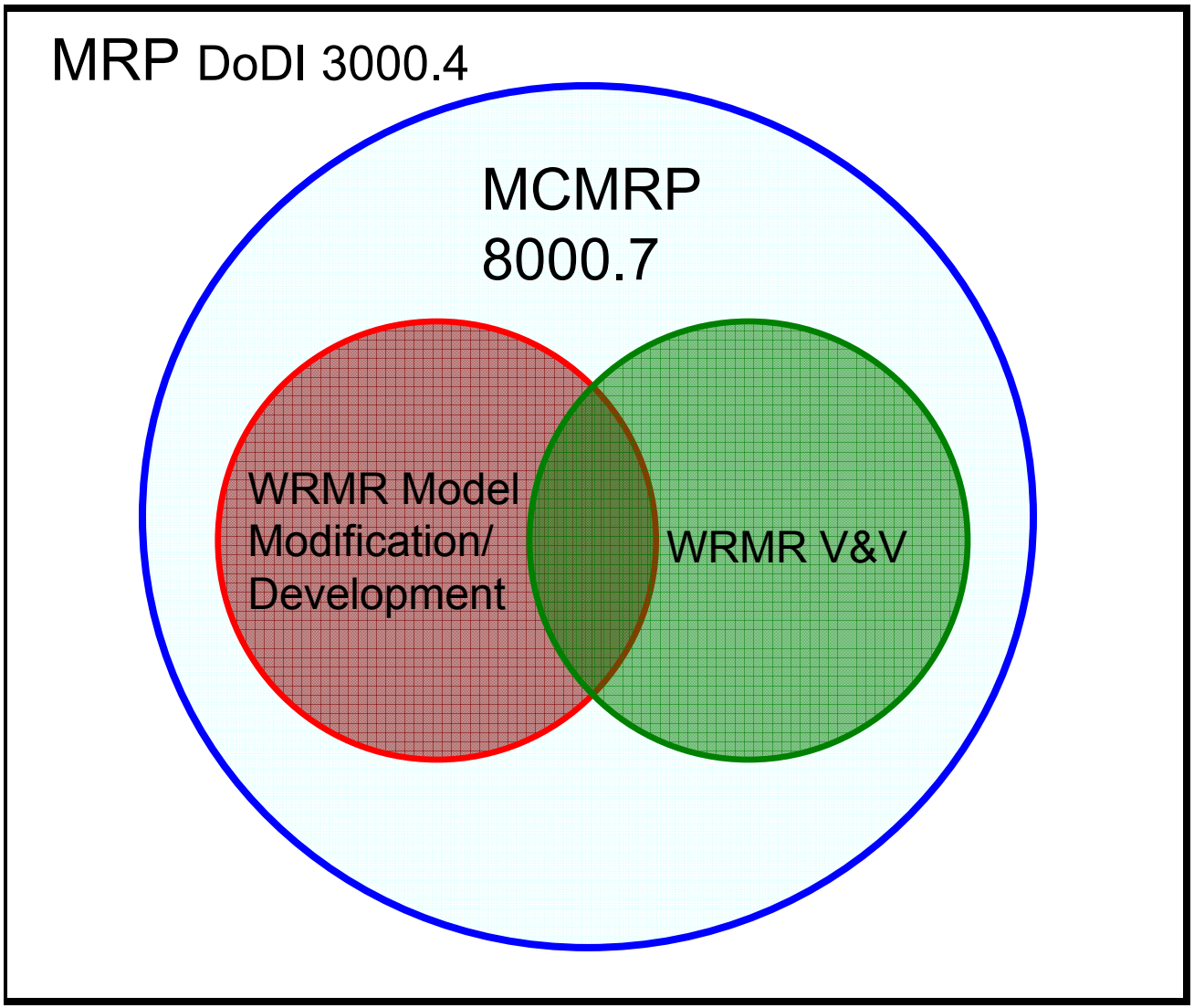
- *First, present our approach, methodology and findings that we used and encountered during our V&V of the USMC WRMR Model.*

- *Second, present and offer some insights, traps, and lessons learned during our V&V effort.*

WRMR V&V Objectives

- **To improve WRMR model and procedures.**
- **To comply with CMC order directing that DC, CD&I coordinate VV&A following the Naval Audit Service report in June 2006.**
- **Complete V&V to support model accreditation for POM-10 analysis.**

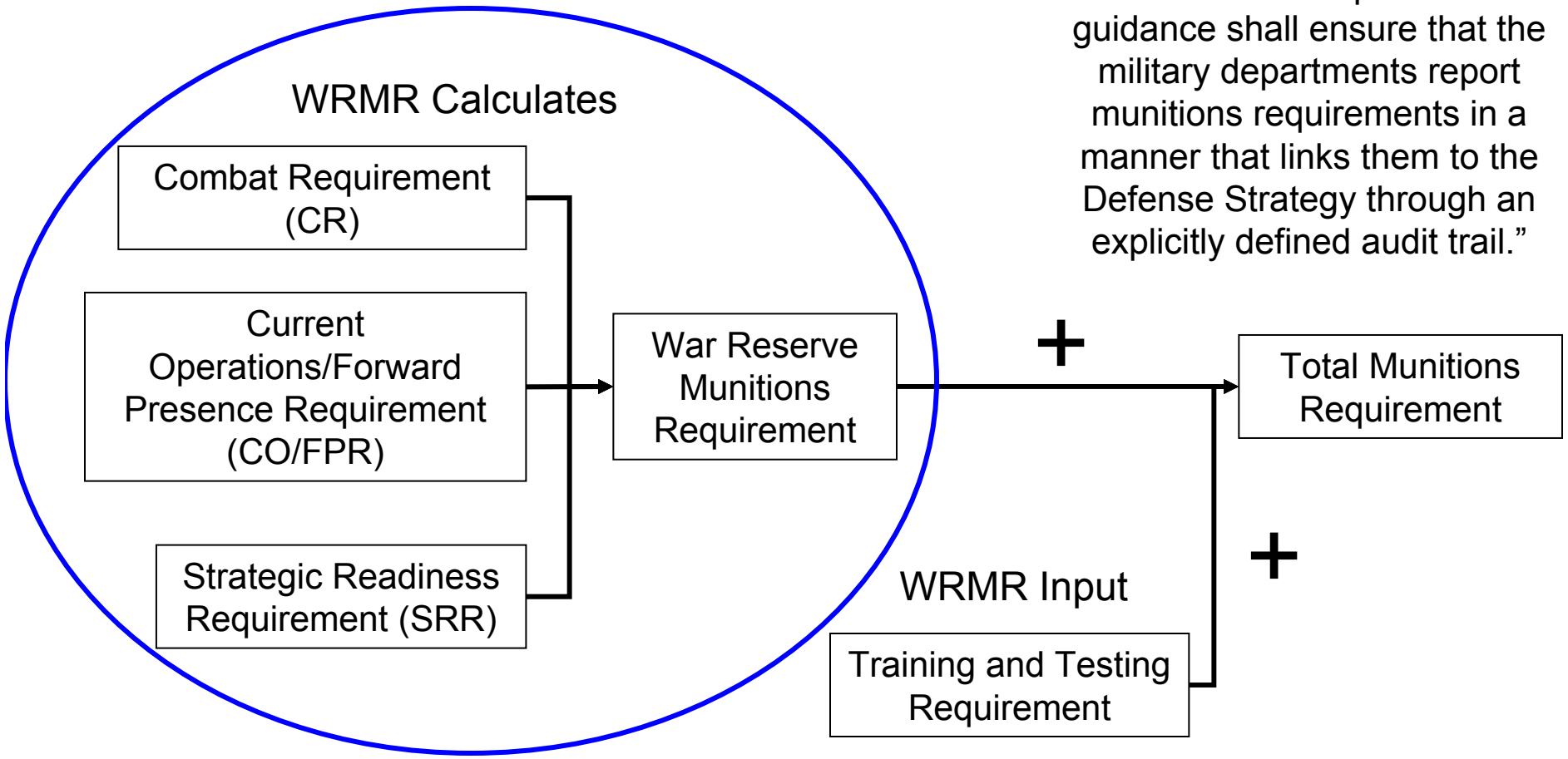
V&V Related Activities



- Align the Marine Corps munitions requirements process (MCMRP) with DoD instructions and guidance
- Support the MCMRP and the POM-10 submission through WRMR model development
- V&V of the WRMR model

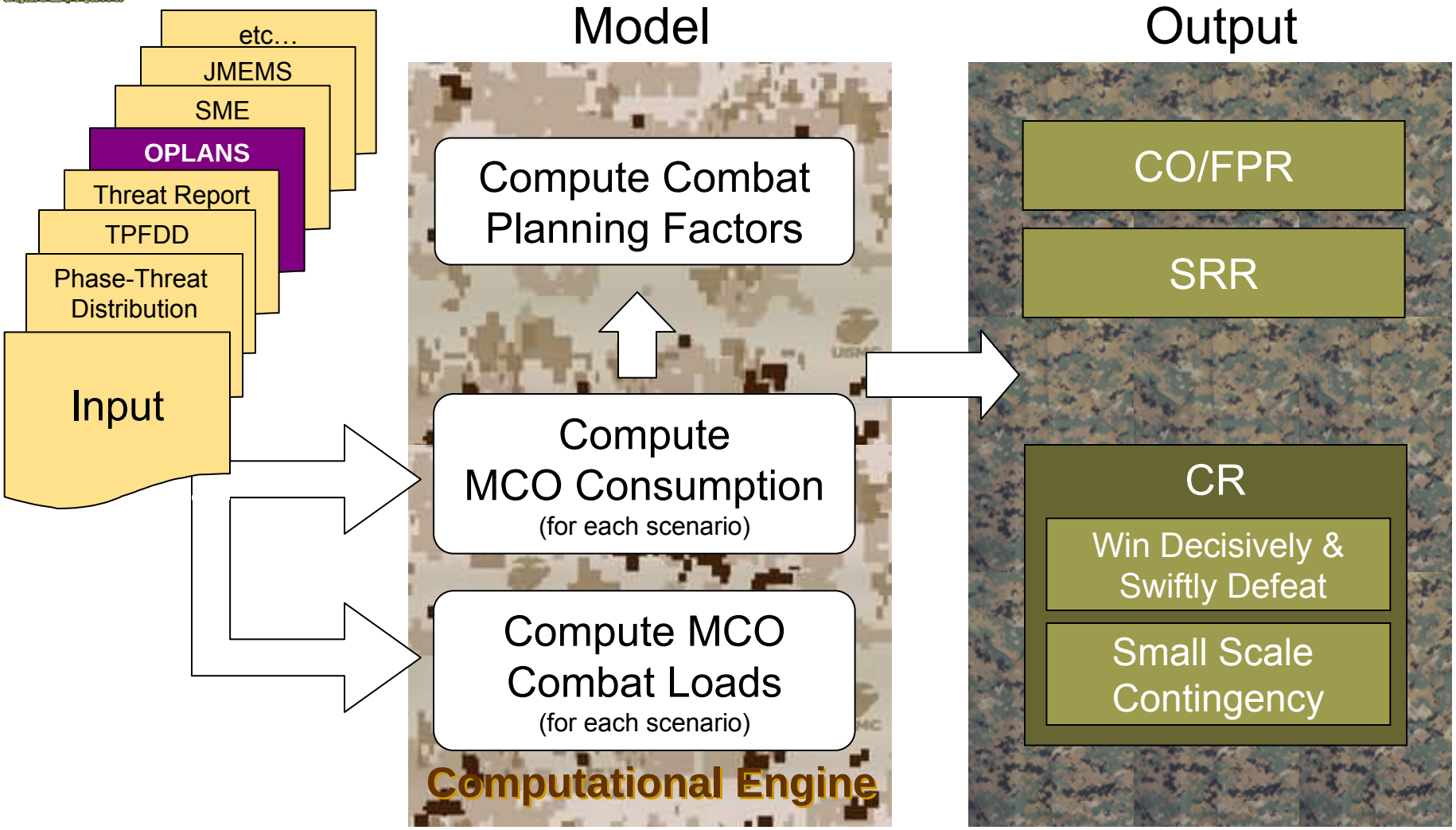
Munitions Requirements Process
DoDI 3000.4

"The DoD MRP Implementation guidance shall ensure that the military departments report munitions requirements in a manner that links them to the Defense Strategy through an explicitly defined audit trail."



DoDI 3000.4 implements policy, assigns responsibility and prescribes procedures for the MRP. It specifies that the CR, CO/FPR and SRR be determined IAW the USD (AT&L) Implementation Guidance.

WRMR Model Process



WRMR is deterministic model that calculates the unconstrained munitions requirements for the USMC

Employed V&V Techniques

- **Audit** – an informal V&V technique used to assess how adequately a model or simulation is used with respect to established plans, policies, procedures, standards, and guidelines. Required an in-depth document review and comparison of the model to DoDI 3000.4.
- **Functional testing** – a V&V technique used to assess the accuracy of model's input-output transformation.
- **Sensitivity analysis** – a V&V technique where selected model inputs are systematically changed over a range of interest while observing the effect upon model outputs.
- **Face validation** – the review of model output by the model development team, users and subject matter experts for reasonableness.
- **Code Walkthrough** – an examination of the model source code to detect and document errors. **Conducted with the model developer.**
- **Regression Testing** – a testing technique used to ensure that corrections and modifications to the model do not create other errors or adverse side effects. Requires that the modified model be tested with data sets used by the previous version of the model. **Completed by the model developer.**

Source: Defense Modeling and Simulation Office, *V&V Techniques, Recommended Practices Guide, Reference Planning Document*, dtd 8/15/01

Combat Requirement Audit

Combat Requirement (CR)

Current Operations/Forward Presence Requirement (CO/FPR)

Strategic Readiness Requirement (SRR)

War Reserve Munitions Requirement

WRMR Model Implementation
MCO req: For each WD and SD, compute combat consumption plus one combat load. Select the WD and largest of two SD MCO expenditures for each DODIC.

WRMR Model Implementation
SSC req: Calculated using combat planning factors, **30 day assault** plus 1 day combat load for each of 3 MEB sized forces.

Combat Requirement Audit

POM-08 Process

	155 HE	81mm HE	Requirement Source
MCO (SD)	**9,725**	**104,362**	**DoDI 3000.4**
MCO (WD)	**78,720**	**168,678**	**DoDI 3000.4**
MPS (SSC) - ***30 day assault rate plus 1 combat load for a MEB***			
A (1)	**48,510**	**38,940**	AO memo dtd 2 May 06
B (2)	**48,510**	**38,940**	AO memo dtd 2 May 06
C (3)	**48,510**	**38,940**	AO memo dtd 2 May 06
Combat Load – ***based on number of weapons in the force***			
MCO (SD)	**1,345**	**8,147**	**DoDI 3000.4**
MCO (WD)	**13,433**	**12,001**	**DoDI 3000.4**
Total	**248,753**	**410,008**	

Recommend policy review of combat requirement

Model Component Verification Example

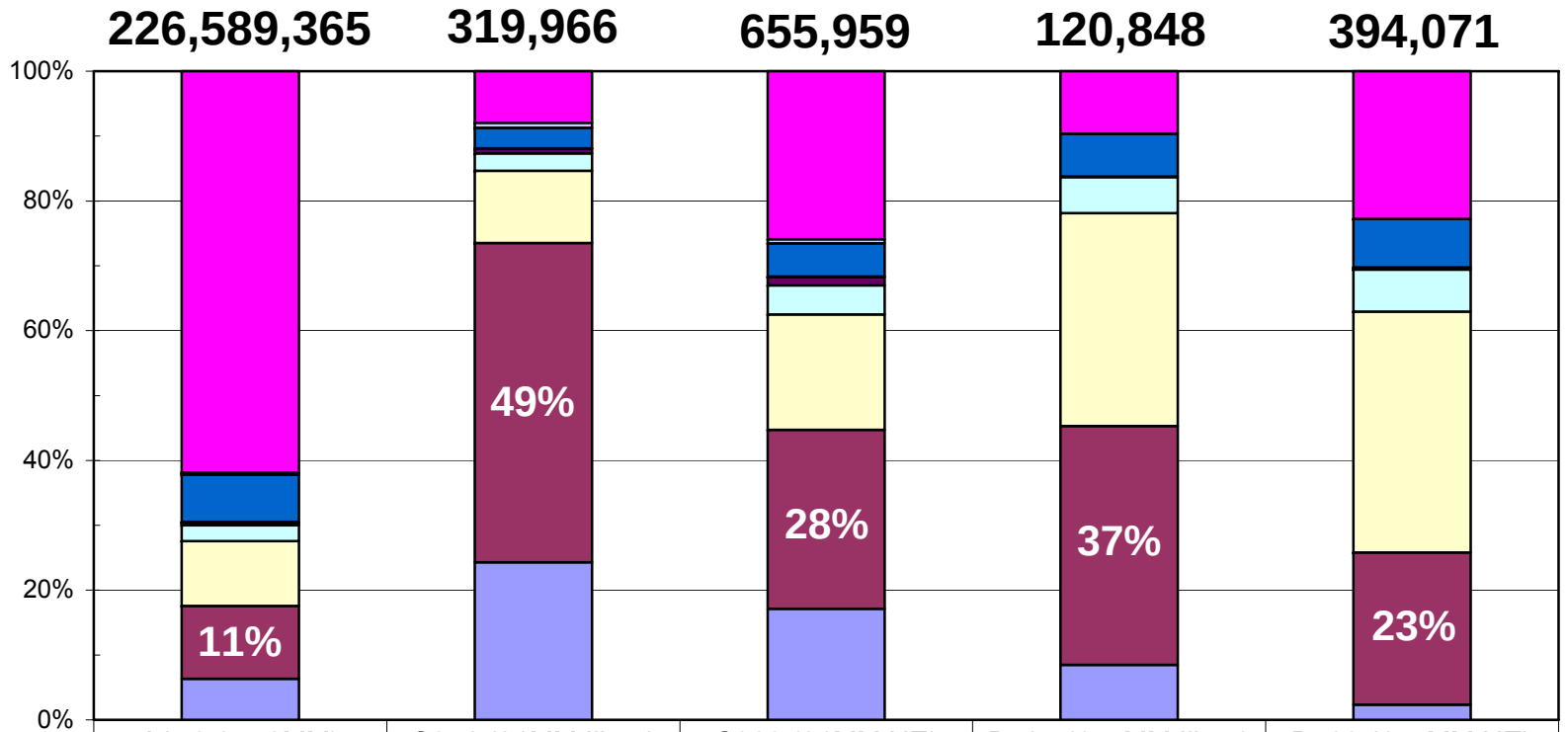
Functional Testing of MCO Target Allocations and Kills example

- Procedure
  - **Examined Inputs/outputs to verify MCO allocations/kills/expenditures for a particular weapon/munitions**
- Target Data
  - **Total Targets = 1038 (DIA TR)**
  - **USMC Allocation = 6.2% = 64.4 (COCOM PTD)**
- Shooter Input Data
  - **Rounds per kill = 1.11**
  - **Shooter Allocation = 24.2% = 15.6 Targets to Kill**
  - **Expected number of rounds expended = 17.3**
- ☺ Shooter/Model Output Data
  - ☺ **Targets killed = 15.6**
  - ☺ **Rounds expended = 17.3**
  - ☺ **Total Targets killed (all shooters) = 64.4**
- ☺ Verification
  - ☺ **Expected Targets to Kill (Shooter)= Targets killed (Shooter) –** VERIFIED
  - ☺ **Expected rounds expended (Shooter) = Rounds/kill * Targets to kill (Shooter) –** VERIFIED
  - ☺ **USMC Target Allocation = Total Targets killed (All shooter types) -** VERIFIED

19 of 25 model components examined and verified.

Face Validation Example

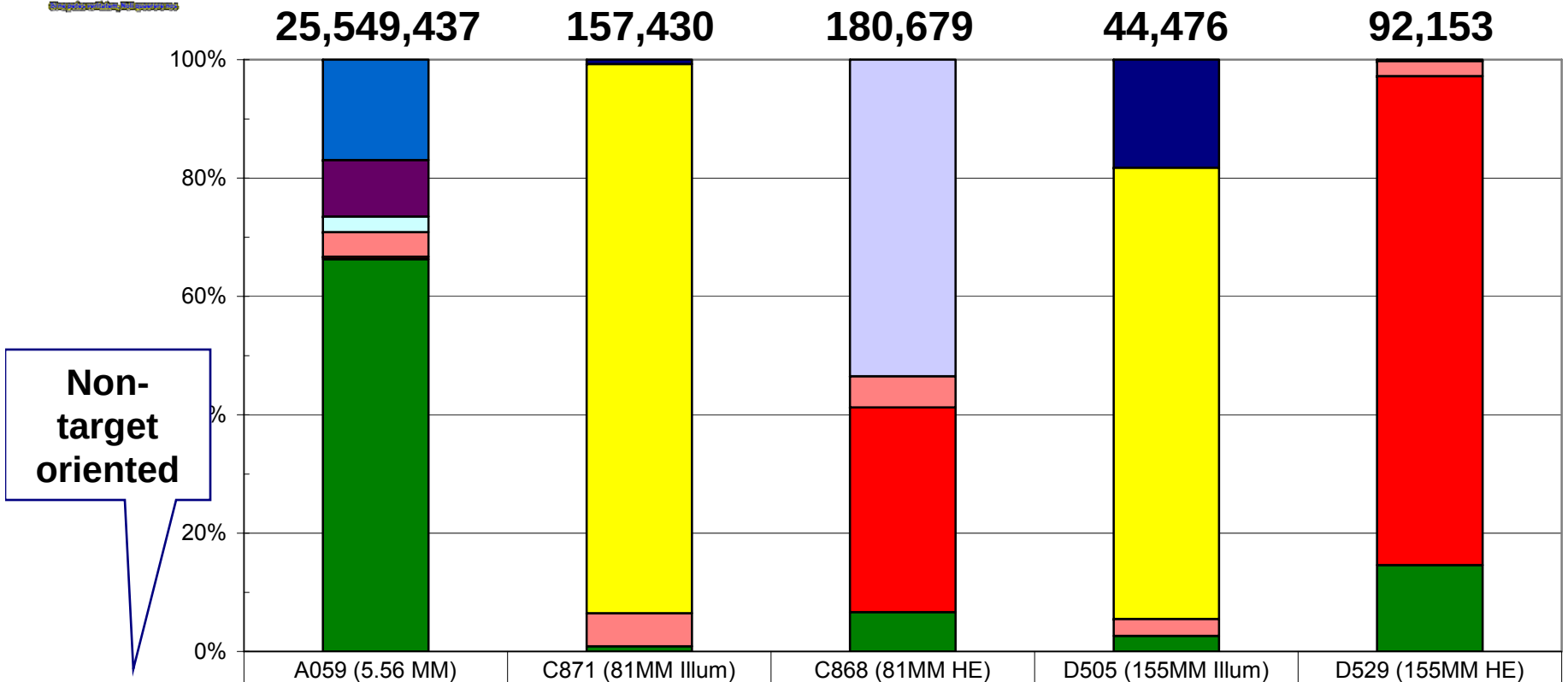
Total Munitions Breakout



	A059 (5.56MM)	C871 (81MM Illum)	C868 (81MM HE)	D505 (155MM Illum)	D529 (155MM HE)
Training/Testing	140,160,325	25,331	170,035	11,677	89,449
GWOT	166,479	0	0	0	0
Homeland Def	603,795	2,601	4,023	0	0
MCPP-N	16,413,580	10,168	33,632	7,937	29,106
UDP	426,000	96	708	120	1,368
ACMs	877,356	2,346	8,328	0	0
LFORMs	5,446,590	8,595	29,225	6,715	25,395
SSC	22,621,581	35,641	116,820	39,684	145,531
WD	25,549,437	157,430	180,679	44,476	92,153
SD	14,324,222	77,758	112,509	10,239	9,127

Face Validation Example

Ammunition Breakout (WD)



Non-target oriented

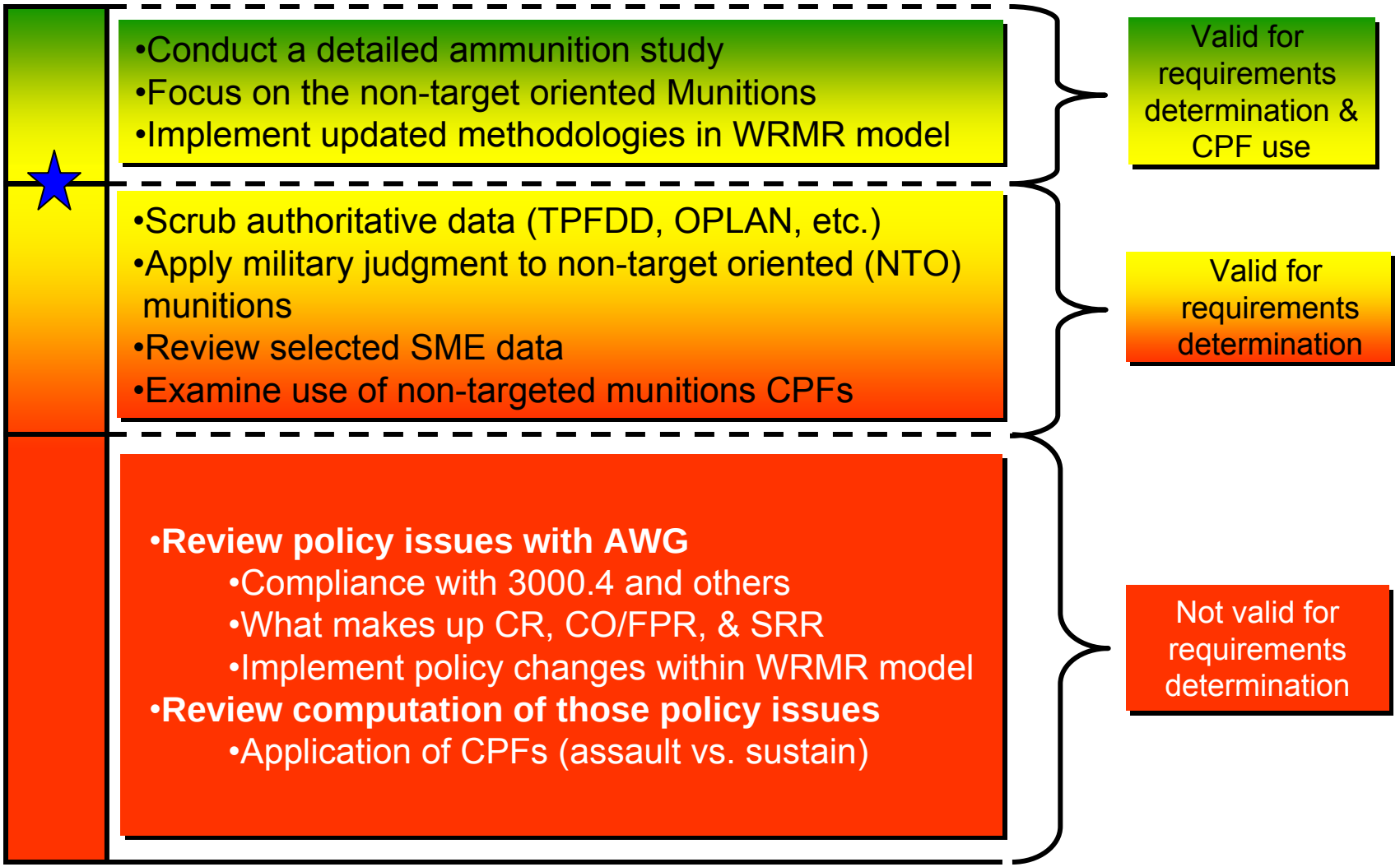
	A059 (5.56 MM)	C871 (81MM Illum)	C868 (81MM HE)	D505 (155MM Illum)	D529 (155MM HE)
Losses	0	2	6	0	0
C2	0	1,164	0	8,112	0
Registration	0		96,598	0	262
Rear Area Sec	4,335,660		0	0	0
Illum	0	146,069	0	33,924	0
Zero	2,439,860	0	0	0	0
OpCheck	670,903	0	0	0	0
Replace	1,058,234	8,834	9,547	1,261	2,293
Tgt Oriented	112,389		62,527	0	76,165
Combat Load	16,932,384	1,361	12,001	1,179	13,433

Big?

Ok

Seems small

Recommendations

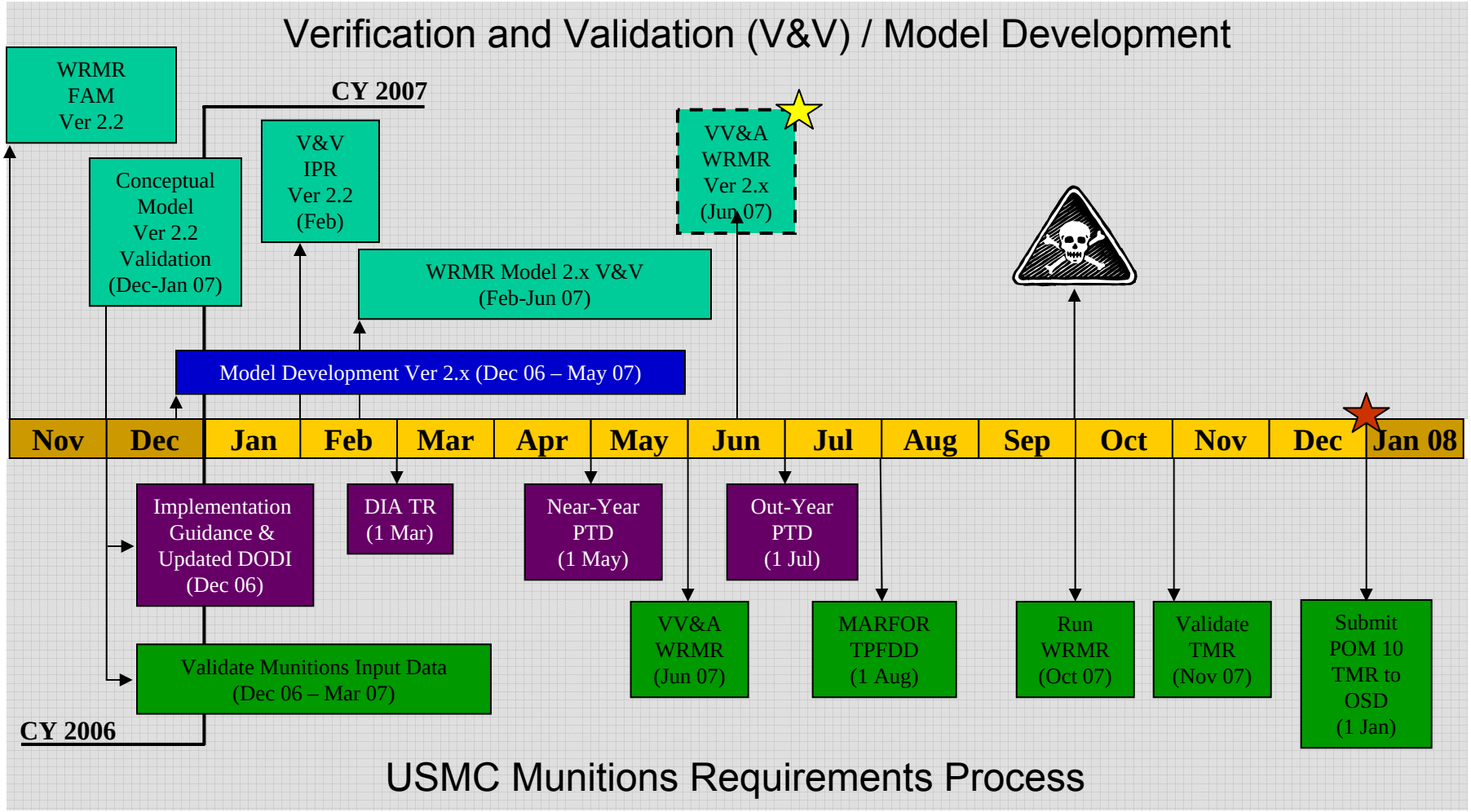


Lessons Learned

- Legacy model V&V is challenging – following website proved to be very helpful: http://vva.dmso.mil/default.htm
- Our review of the WRMR conceptual model was important; however, we learned a great deal more about the model by running it.
- The WRMR model depends upon a large amount of data – not all owned by the USMC.
- Determining your basis of comparison is not always straight forward! In defining our basis of comparison for the WRMR model, we looked at the other services models.
- Documentation, documentation, documentation!
- Establish contact, build a rapport with the developer and user – smooth relations promotes better overall support.
- Walking through the WRMR code with the developer was extremely helpful.
- The WRMR V&V benefited from the interdisciplinary makeup of the team – computer science, operations research, subject matter expertise, and Marine Corps expertise.

Backup

WRMR V&V Timeline



Document Review

- **In-depth review of appropriate documents was accomplished to gain an understanding of the munitions requirements process and to confirm M&S requirements in order to perform conceptual model validation.**
  - **DoDI 3000.4, MCO 8000.7, MCO 8000.8 (draft)**
  - **POM 08 TMR**
  - **CMC ltr 19 Jun 06 (Response to Naval Audit)**
  - **MCMRP Brief dtd Nov 06**
  - **DoD MRP POM-10 Conference Brief, dtd 26 Sep 06**
- **Model documentation was reviewed to gain understanding of model processes.**
  - ☺ **Computational model well documented**
  - ☺ **Model input and output documentation updated to include file descriptions.**

Target-Oriented Expenditures

- **By DoD INST 3000.4, total targets to be defeated are obtained from the DIA Threat Report (TR) and COCOM Phased Threat Distribution (PTD):**

$$Tgts\ to\ be\ Defeated\ (by\ phase) = Tot\ Tgts\ (TR) * Service\ Allocation\ (PTD)$$

- **The WRMR computational engine determines daily expenditures based on the number of targets killed over the course of a particular phase in order to support the calculation of combat planning factors (CPFs).**

Source: Class V(W) Requirements Methodology (POM-08) no date

Non-target Expenditures

- Registration
- Zeroing
- Operational check
- Illumination
- Mine
- Screening
- Explosive ordnance disposal
- Demolition
- Command and control
- Rear-area security
- Self-defense
- Obscuration

Non-target expenditures account for munitions requirements not directly related to target destruction.

Non-target Expenditures
Illumination Example

Situation: MAGTF consisting of 9 Inf Co's employed to date in the defense, 2/3 of which are engaged.

Problem: Calculate the daily requirement for illumination in this situation.

Equation:

$$\textbf{Daily Expenditure} = (\text{Num Inf Co}) * (\text{Frac Engaged}) * \frac{(\text{Required illum (min)})}{(\text{Illum provided by rnd (min)})}$$

Variables:

Num Inf Co = 9
Frac Engaged = 2/3
Required Illum (min) = 32 (min)
Illum provided by rnd (min) = 1 (min) (DODIC C871)

Answer:

C871 = 9 * ⅔ * (32/1) = **192 Rnds per day**

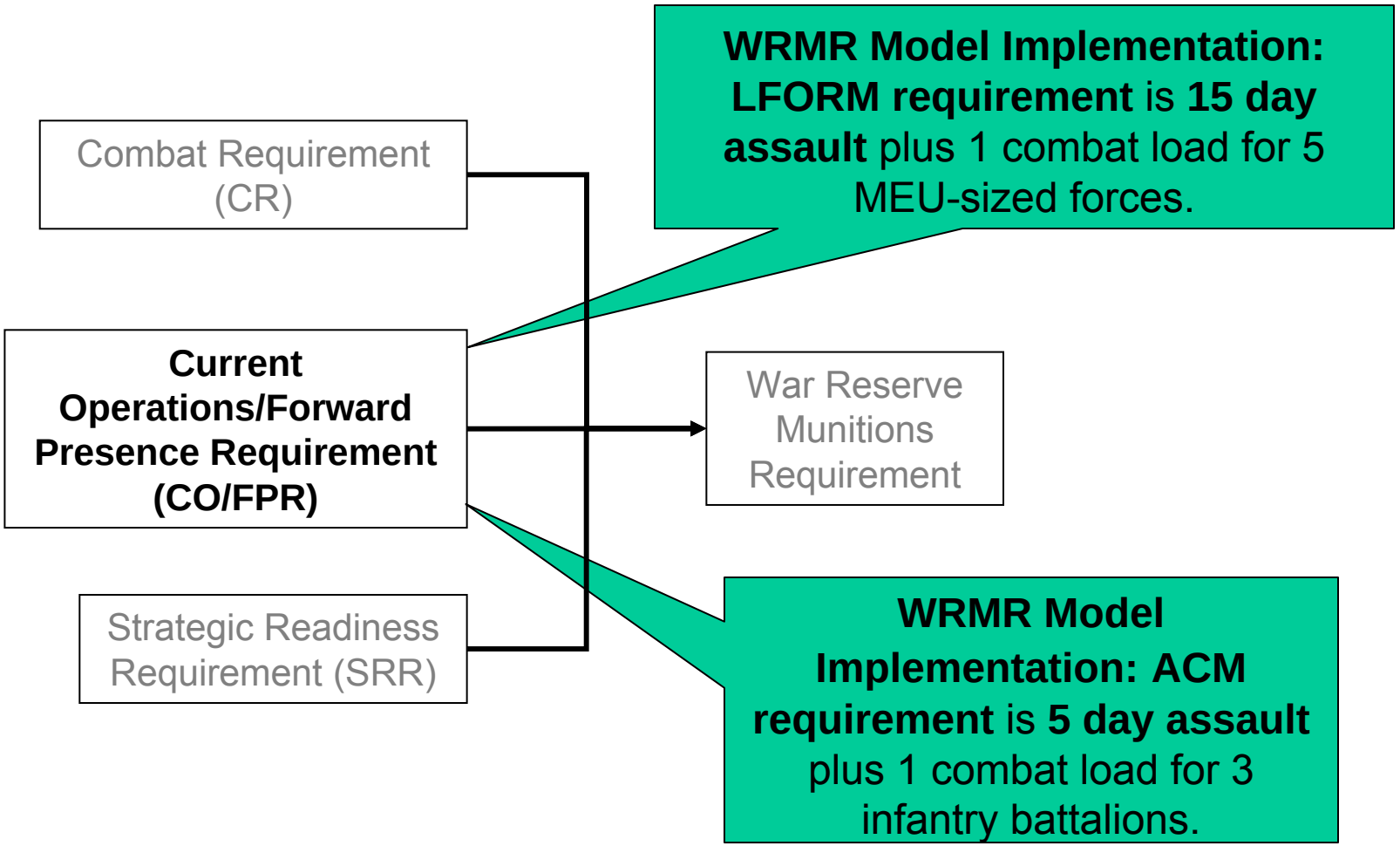
Source: Class V(W) Requirements Methodology (POM-08)

Combat Planning Factors

- Determine average daily expenditure per shooter type for all scenarios.
- Sort average daily expenditure from high to low.
- Identify and group high-intensity days and low-intensity days.
- Calculate CPFs
  - Assault rate = Average expenditure rate of high-intensity days
  - Sustain rate = Average expenditure rate of low-intensity days

Combat planning factors are a key element of munitions requirements determination.

Current Operations/Forward Presence (CO/FPR)



ACM – air contingency MAGTF

LFORM – landing force operational reserve materiel

Strategic Readiness Requirement

WRMR Model Implementation: Homeland defense is **30 days sustain** plus 1 combat load for 3 infantry battalions.

WRMR Model Implementation: UDP is 1 combat load for 1 infantry battalion, 1 arty battalion, 1 AAV company and 1 LAR company.

Combat Requirement (CR)

Current Operations/Forward Presence Requirement (CO/FPR)

War Reserve

WRMR Model Implementation: MCPP-N is **30 day assault** rate plus 1 combat load for force identified in MCBul 3502.

Strategic Readiness Requirement (SRR)

WRMR Model Implementation: GWOT is **3 days assault** plus **15 days sustain** plus 1 combat load for 3 AT teams.

AT – anti-terrorist

LFORM – landing force operational reserve materiel

UDP – unit deployment program

MCPP-N – Marine Corps pre-positioned - Norway

Model Component Verification Summary

Model Components	Verified	Method
Determine Expenditures per Target	**Yes**	**Functional Test**
Push Targets to Underutilized Shooters	**Yes**	**Functional Test**
Scale Target Allocation	**Yes**	**Code Walkthrough**
Assess USMC Losses	**Yes**	**Functional Test, Code Walkthrough**
Determine Combat Losses of Munitions	**Yes**	**Functional Test**
Determined Replacement and/or Repairs	**Yes**	**Functional Test**
Determine Registration Expenditures	**Yes**	**Functional Test**
Determine Zeroing Expenditures	**Yes**	**Functional Test**
Determine Operational Check Expenditures	**Yes**	**Functional Test**
Determine Illumination Expenditures	**Yes**	**Functional Test**
Determine Obscuration Expenditures	**Not tested**	**Doc. & Input Data Review**
Determine Screening Expenditures	**Not tested**	**Doc. & Input Data Review**
Determine Demolition Expenditures	**Not tested**	**Doc & Input Data Review**
Determine Explosives Ordnance Disposal (EOD) Expenditures	**Not tested**	**Doc & Input Data Review**

Model Component Verification Summary (Cont)

Model Components	Verified	Method
Determine Mine Expenditures	**Not tested**	**Doc. & Input Data Review**
Determine Command & Control Expenditures	**Yes**	**Functional Test**
Determine Rear Area Security Expenditures	**Yes**	**Functional Test**
Determine Self Defense Expenditures	**Yes**	**Functional Test**
Determine Ancillary Expenditures	**Yes**	**Functional Test**
Compute Win Decisively (WD) and Swiftly Defeat the Effort (SDTE) Requirements	**Yes**	**Functional Test, Audit, Face Validation, Sensitivity Analysis**
Compute Combat Planning Factors (CPF)	**Yes**	**Functional Test, Audit, Face Validation, Code walkthrough**
Compute Small-Scale Contingency Requirements (SSCR)	**Yes**	**Functional Test, Audit, Face Validation, Sensitivity Analysis**
Compute Current Operations/ Forward Presence Requirements (CO/FPR)	**Yes**	**Functional Test, Audit, Face Validation, Sensitivity Analysis**
Compute Strategic Readiness Requirement (SRR)	**Yes**	**Functional Test, Audit, Face Validation, Sensitivity Analysis**

Model Component Validation Summary (1 of 3)

Model Components	Valid ?	Discussion
Determine Expenditures per Target	**V**	**Uses JMEMS methodology;**
Push Targets to Underutilized Shooters	**V**	**Allows allocation of targets from over-taxed shooters to under-utilized shooters**
Scale Target Allocation	**V**	**Scales down target allocations so that busiest shooter types to do not exceed daily limit and weapon-tgt preferences remain consistent**
Assess USMC Losses	**NV**	**Review '04 SME data; review proportionality assumption**
Determine Combat Losses of Munitions	**NV**	**Method may double count ammo lost When weapon system is lost**
Determined Replacement and/or Repairs	**V**	**Determines fraction of killed tgts expected to return**
Determine Registration Expenditures	**NV**	**Review data and methodology**

Preliminary Assessment

V: Valid, **NV**: Not valid

- Model component not valid for POM-10
- Time permitting, review for POM-10
- Sufficient for POM-10
- Corrected during V&V

Model Component Validation Summary (2 of 3)

Model Components	Valid ?	Discussion
Determine Zeroing Expenditures	**V**	**Review '04 SME data only**
Determine Operational Check Expenditures	**V**	**Review '04 SME data only**
Determine Illumination Expenditures	**NV**	**Face validation indicates high expenditures; methodology may be too complex, review with SME, align model phases with OPLANS**
Determine Obscuration Expenditures	**NV**	**Face validation**
Determine Screening Expenditures	**V**	**Review '04 SME data only**
Determine Demolition Expenditures	**NV**	**Align OPLANS/model**
Determine EOD Expenditures	**NV**	**Align OPLANS/model**
Determine Mine Expenditures	**NV**	**Align OPLANS/model**
Determine Command & Control Expenditures	**NV**	**Align OPLANS/model**
Determine Rear Area Security Expenditures	**V**	**Review '04 SME data only**

Preliminary Assessment

V: Valid, **NV**: Not valid

Model component not valid for POM-10
Time permitting, review for POM-10
Sufficient for POM-10
Corrected during V&V

Model Component Validation Summary (3 of 3)

Model Components	Valid ?	Discussion
Determine Self Defense Expenditures	**V**	**Review '04 SME data only**
Determine Ancillary Expenditures	**V**	**Review '04 SME data only**
Compute Win Decisively (WD) and Swiftly Defeat the Effort (SDTE) Requirements	**V**	**Align OPLANS/model**
Compute Combat Planning Factors (CPF)	**V**	**Review non-target oriented munitions results**
Compute Small-Scale Contingency Requirements (SSCR)	**NV**	**Requirements under revision**
Compute Current Operations/ Forward Presence Requirements (CO/FPR)	**V**	**Requirements under revision**
Compute Strategic Readiness Requirement (SRR)	**NV**	**Must comply with DoDI 3000.4 Requirements under revision**

Preliminary Assessment

V: Valid, **NV**: Not valid

Model component not valid for POM-10
Time permitting, review for POM-10
Sufficient for POM-10
Corrected during V&V